Seasonal Report

2019 Fine Particles ($PM_{2.5}$)

OVERVIEW

2019 was once again another very clean year for fine particles ($PM_{2.5}$) across the state of Maryland. $PM_{2.5}$ is a health concern as it is a year round pollutant, though winter is becoming the primary period for elevated concentrations in Maryland. Due to its small size (<2.5µm in diameter), $PM_{2.5}$ can penetrate deep into the lungs resulting in adverse cardiovascular effects. The Environmental Protection Agency (EPA) sets the National Ambient Air Quality [Health] Standard (NAAQS) for $PM_{2.5}$. When the midnight to midnight daily 24-hour average $PM_{2.5}$ concentration exceeds 35.4 µg/m³, or 100 on the Air Quality Index (AQI) (see bottom page), it is considered unhealthy for sensitive groups (USG) and is coined an "exceedance day". Over the past 15+ years, the number of $PM_{2.5}$ exceedance days has substantially decreased (*See Figure 1*) due in large part to the adoption of regulations to reduce emissions of SO_2 and NO_x. In fact, since 2010 Maryland has attained the $PM_{2.5}$ standard and in 2019 had just one day where the AQI exceeded the USG threshold of 100.

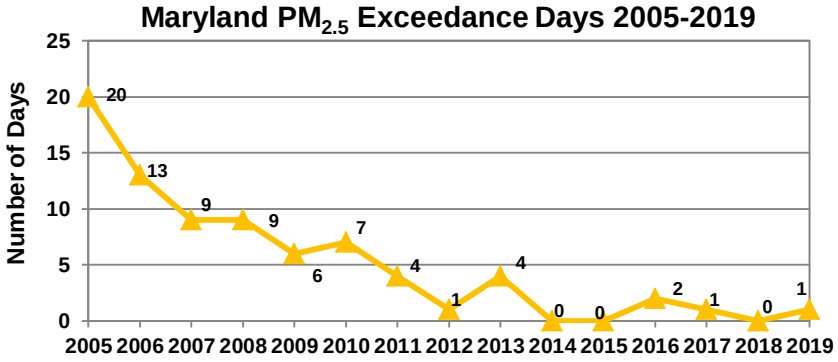

Figure 1: Annual number of days where the AQI surpassed 100 at any $PM_{2.5}$ monitor in Maryland, 2005-2019.

WHAT ARE FINE PARTICLES (PM2.5)?

Unlike gaseous ozone, fine particulates, are solid particles of pollution suspended in the air due to their very small size. Smaller than 2.5 microns (µm) in diameter, is why fine particulates are also known as $PM_{2.5}$. To give that some perspective, the average width of human hair is about 50-70 µm across. At this size, $PM_{2.5}$ are actually able to pass through the lungs into the blood stream. $PM_{2.5}$ can originate from many different sources including diesel exhaust, fires and other combustion, power plant emissions, and can even be created by reactions between different types of pollution, water vapor and sunlight. Due to the numerous adverse health effects of high $PM_{2.5}$ concentrations, it is an important pollutant to monitor and track. 2019 marks the 20th year of fine particulate monitoring in the state of Maryland.

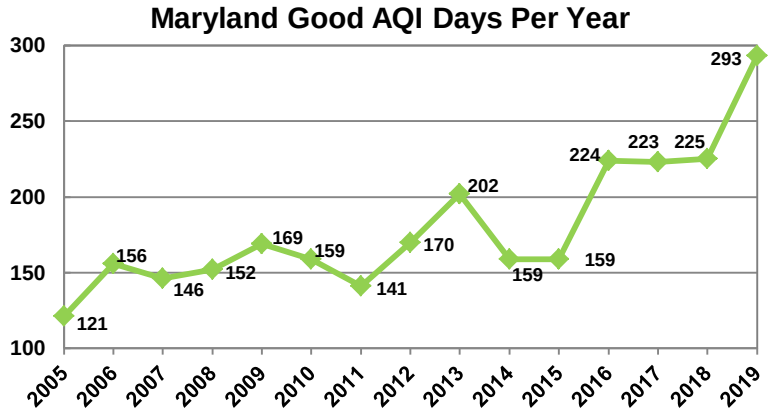

Figure 2: Annual number of days where the highest 24-hour average $PM_{2.5}$ value remained at or below an AQI of 50 (Good) in Maryland, 2005-2019.

SEASONAL HIGHLIGHTS

Despite the one $PM_{2.5}$ exceedance day versus zero in 2018, overall 2019 was still a very clean year. When looking at the maximum daily $PM_{2.5}$ concentrations across the state, Maryland had 293 (~80%) Good AQI days. This is by far and away the highest number of annual Good days since measurements began back in 1999 (*See Figure 2*). In addition to this, summertime $PM_{2.5}$ exceedance days have essentially become a thing of the past. In fact, there has not been a $PM_{2.5}$ exceedance day during the summer in the state of Maryland since 2011! In 2019, the maximum daily $PM_{2.5}$ concentration in Maryland between April and September was only 17.1 µg/m³ *(Refer to Figure 3)* . This is not even half of what is needed to reach USG levels (35.4 µg/m³). Given the continued reductions in SO_2 and NO_x, elevated $PM_{2.5}$ concentrations have become more influenced by the vertical temperature profile and more more specifically temperature inversions, which are defined as an increase in temperature with height. Surface inversions, common in winter months, act as a lid and trap pollutants near the surface.

In total there were only seven days which had a 24-hour maximum daily concentration that surpassed 25 µg/m³. Six of these seven occurred during just two individual events, Feb 1-3rd and Dec 22-26th. It is worth noting that both of these events occurred during the winter months and were characterized by strong surface inversions *(See featured episode which highlights the Dec 22-26th event).*

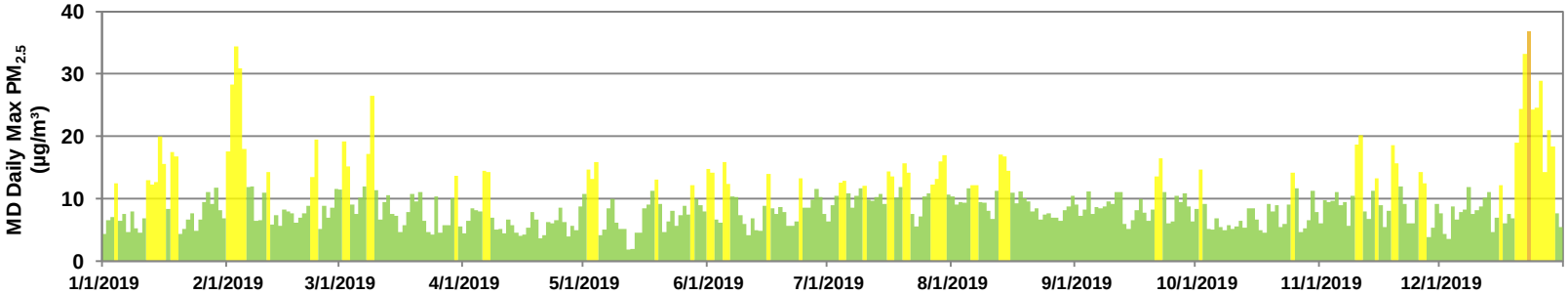

Figure 3: Maximum daily 24-hour PM2.5 (µg/m³) in Maryland from January 1 – December 31, 2019. Bars are color coded by AQI

AQI	0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

*Unhealthy for Sensitive Groups

MARYLAND DEPARTMENT OF THE ENVIRONMENT
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Seasonal Report

2019 Fine Particles ($PM_{2.5}$)

FEATURED EPISODE: December 23rd 2019

High pressure positioned itself over the eastern U.S. beginning Friday, December 20th. Weak, stagnant flow along with general subsidence (sinking air) both of which are synonymous with large wintertime high pressure systems allowed for $PM_{2.5}$ conditions to gradually deteriorate across the region (*See Figure 4*). Overnight temperatures Friday-Sunday were quite cold, with lows at BWI airport dipping down into the mid to upper 20's. Given it being the winter, localized wood burning as a source of heat became especially prominent across the entire area. Black carbon (*a good tracer for smoke*) had a roughly 10-15*x* increase between December 19th and the 23rd, further supporting the deterioration of the air mass. (*See Figure 5*). In addition to this, mixing heights across the area began to lower with overnight and early morning surface inversions developing.

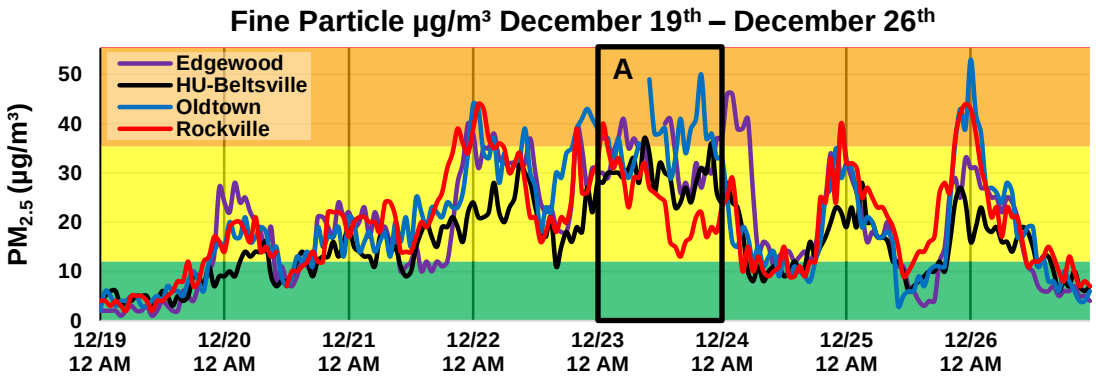

Figure 4: Hourly $PM_{2.5}$ concentrations (µg/m³) for several Maryland monitors between the timeframe of December 19th – December 26th 2019. Horizontal coloring matches with appropriate AQI ranges. Box labeled "A" marks the date of the exceedance event.

By December 22nd, $PM_{2.5}$ levels were nearing USG criteria with a 24-hour average concentration at the Oldtown monitor in downtown Baltimore reaching 33.29 µg/m³ (USG threshold is 35.4 µg/m³). Midday surface mixing was just enough to avoid an exceedance day. Surface inversions strengthened during the overnight hours of the 22nd into the 23rd. By the morning of the 23rd, temperatures at the surface in nearby Sterling, VA were 26 °F (-3.3°C). When compared to just 300 feet above the surface, the temperature jumped to 36°F (2.2°C). This is an impressive 10°F (5.5°C) increase in temperature in a very shallow layer above the surface. Despite daytime warming, surface inversions on the 23rd were strong enough to persist throughout the day. This allowed any pollutants present or being emitted to be trapped and focused right at the immediate surface. Figure 6 shows the visibility on the exceedance day (Dec 23rd) versus just a few days prior (Dec 18th). Trapped pollution is clearly visible on the 23rd as a "brownish" color due to elevated concentrations of nitrogen dioxide very near to the surface which is emitted from cars and other combustion sources.

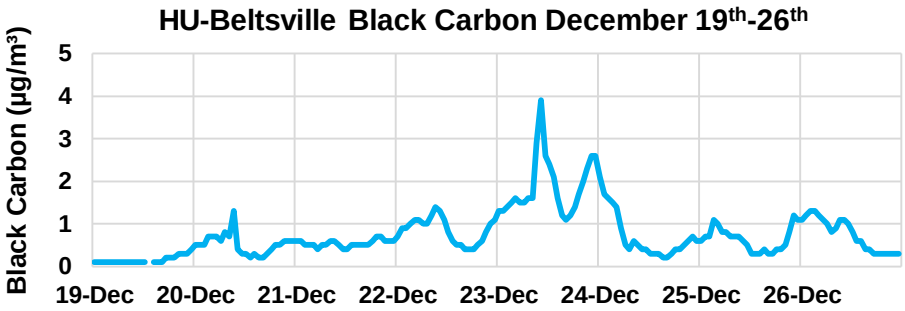

Figure 5: Hourly black carbon concentrations (µg/m³) at Howard University, Beltsville between the timeframe of December 19th – December 26th 2019.

High pressure remained over the area for several days following the 23rd, however surface inversions were not quite as strong. Midday surface mixing was enough to drop fine particulate levels for several hours during the mid-afternoon, helping to keep $PM_{2.5}$ concentrations in check. A diurnal cycle is clearly evident in Figure 4 between the 24th-26th with elevated $PM_{2.5}$ concentrations during the overnight hours and slightly cleaner conditions occurring in the mid-afternoon as mixing increased. Despite a very favorable atmospheric setup over this timeframe, just one Maryland monitor (Oldtown) recorded 24-hour $PM_{2.5}$ concentrations above the USG threshold at 36.87µg/m³ on December 23rd. This was the first $PM_{2.5}$ exceedance day in the state of Maryland in over two years, dating back to December 4th, 2017.

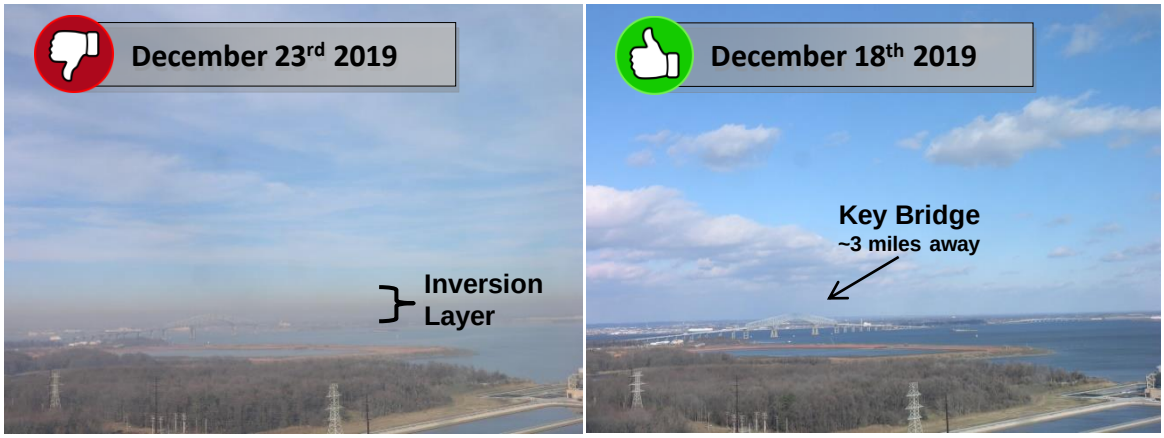

Figure 6: Visual comparison of the featured event date, December 23rd (Left) and a Good Air Quality day just a few days prior on December 18th 2019 (Right). The inversion layer is noted on the left as indicated by the "brownish" color. Key Bridge location and approximate distance is noted on the right.

AQI	0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

Unhealthy for Sensitive Groups based on 2015 8-hr ozone NAAQS. Denotes the USG

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